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PROTOPLASM  
AS RELATED  
TO  
PROFESSOR HUXLEY'S ESSAY

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No. 3---University Series.

As Regards Protoplasm,

IN RELATION TO

PROFESSOR HUXLEY'S ESSAY

ON THE

PHYSICAL BASIS OF LIFE.

BY

*JAMES HUTCHISON STIRLING,*

F. R. C. S. AND LL. D., EDIN.



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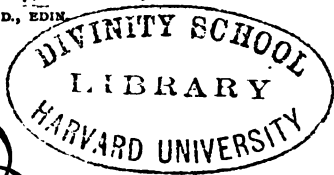
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## PREFATORY NOTE.

The substance of the greater part of this paper, which has been in the present form for some time, was delivered, as a lecture, at a *Conversazione* of the Royal College of Physicians of Edinburgh, in the Hall of the College, on the evening of Friday, the 30th of April last.

It will be found to support itself, so far as the facts are concerned, on the most recent German physiological literature, as represented by Rindfleisch, Kühne, and especially Stricker, with which last, for the production of his "*Handbuch*," there is associated every great histological name in Germany.

EDINBURGH, *October*, 1869.



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## AS REGARDS PROTOPLASM, ETC.

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It is a pleasure to perceive Mr. Huxley open his clear little essay with what we may hold, perhaps, to be the manly and orthodox view of the character and products of the French writer, Auguste Comte. "In applying the name of 'the new philosophy' to that estimate of the limits of philosophical inquiry which he" (Professor Huxley), "in common with many other men of science, holds to be just," the Archbishop of York confounds, it seems, this new philosophy with the Positive philosophy of M. Comte ; and thereat Mr. Huxley expresses himself as greatly astonished. Some of us, for our parts, may be inclined at first to feel astonished at Mr. Huxley's astonishment ; for the school to which, at least on the philosophical side, Mr. Huxley seems to belong, is even notorious for its prostration before Auguste Comte, whom, especially, so far as method and systematization are concerned, it regards as the greatest intellect since Bacon. For such, as it was the opinion of Mr. Buckle, is understood to be the opinion also of Messrs. Grote, Bain, and Mill. In fact, we may say that such is commonly and currently considered the characteristic and distinctive opinion of that whole perverted or inverted reaction which has been called the *Revulsion*. That is to say, to give this word a moment's explanation, that the Voltaires and Humes and Gibbons having long enjoyed an immunity of sneer at man's blind pride and

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wretched superstition—at *his* silly non-natural honor and *her* silly non-natural virtue—a reaction had set in, exulting in poetry, in the splendor of nature, the nobleness of man, and the purity of woman, from which reaction again we have, almost within the last decennium, been revulsively, as it were, called back,—shall we say by some “bolder” spirits—the Buckles, the Mills, &c. ? —to the old illumination or enlightenment of a hundred years ago, in regard to the weakness and stupidity of man’s pretensions over the animality and materiality that limit him. Of this revulsion, then, as said, a main feature, especially in England, has been prostration before the vast bulk of Comte ; and so it was that Mr. Huxley’s protest in this reference, considering the philosophy he professed, had that in it to surprise at first. But if there was surprise, there was also pleasure ; for Mr. Huxley’s estimate of Comte is undoubtedly the right one. “So far as I am concerned,” he says, “the most reverend prelate” (the Archbishop of York) “might dialectically hew M. Comte in pieces as a modern Agag, and I should not attempt to stay his hand ; for, so far as my study of what specially characterizes the Positive philosophy has led me, I find therein little or nothing of any scientific value, and a great deal which is as thoroughly antagonistic to the very essence of science as anything in ultramontane Catholicism.” “It was enough,” he says again, “to make David Hume turn in his grave, that here, almost within earshot of his house, an instructed audience should have listened without a murmur while his most characteristic doctrines were attributed to a French writer of fifty years’ later date, in whose dreary and verbose pages we miss alike the vigor of thought and the exquisite clearness

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of style of the man whom I make bold to term the most acute thinker of the eighteenth century—even though that century produced Kant."

Of the doctrines themselves which are alluded to here, I shall say nothing now ; but of much else that is said, there is only to be expressed a hearty and even gratified approval. I demur, to be sure, to the exaltation of Hume over Kant—high as I place the former. Hume, with infinite fertility, surprised us, it may be said, perhaps, into attention on a great variety of points which had hitherto passed unquestioned ; but, even on these points, his success was of an interrupted, scattered and inconclusive nature. He set the world adrift, but he set man too, reeling and miserable, adrift with it. Kant, again, with gravity and reverence, desired to refix, but in purity and truth, all those relations and institutions which alone give value to existence—which alone *are* humanity, in fact—but which Hume, with levity and mockery, had approached to shake. Kant built up again an entire new world for us of knowledge and duty, and, in a certain way, even belief ; whereas Hume had sought to dispossess us of every support that man as man could hope to cling to. In a word, with *at least* equal fertility, Kant was, as compared with Hume, a graver, deeper, and, so to speak, a more consecutive, more comprehensive spirit. Graces there were indeed, or even, it may be said, subtleties, in which Hume had the advantage perhaps. He is still in England an unsurpassed master of expression—this, certainly, in his History, if in his Essays he somewhat baffles his own self by a certain labored breadth of conscious fine writing, often singularly inexact and infelicitous. Still Kant, with reference to his products, must be allowed

much the greater importance. In the history of philosophy he will probably always command as influential a place in the modern world as Socrates in the ancient ; while, as probably, Hume will occupy at best some such position as that of Heraclitus or Protagoras. Hume, nevertheless, if equal to Kant, must, in view at once of his own subjective ability and his enormous influence, be pronounced one of the most important of writers. It would be difficult to rate too high the value of his French predecessors and cotemporaries as regards purification of their oppressed and corrupt country ; and Hume must be allowed, though with less call, to have subserved some such function in the land we live in. In preferring Kant, indeed, I must be acquitted of an undue partiality ; for all that appertains to personal bias was naturally, and by reason of early and numerous associations, on the side of my countryman.

Demurring, then, to Mr. Huxley's opinion on this matter, and postponing remark on the doctrines to which he alludes, I must express a hearty concurrence with every word he utters on Comte. In him I too "find little or nothing of any scientific value." I too have been lost in the mere mirage and sands of "those dreary and verbose pages ;" and I acknowledge in Mr. Huxley's every word the ring of a genuine experience. M. Comte was certainly a man of some mathematical and scientific proficiency, as well as of quick but biased intelligence. A member of the *Aufklärung*, he had seen the immense advance of physical science since Newton, under, as is usually said, the method of Bacon ; and, like Hume, like Reid, like Kant, *who had all anticipated him in this*, he sought to transfer that method to the domain of mind. In this he failed ; and though in

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a sociological aspect he is not without true glances into the present disintegration of society and the conditions of it, anything of importance cannot be claimed for him. There is not a sentence in his book that, in the hollow elaboration and windy pretentiousness of its build, is not an exact type of its own constructor. On the whole, indeed, when we consider the little to which he attained, the empty inflation of his claims, the monstrous and maniacal self-conceit into which he was *exalted*, it may appear, perhaps, that charity to M. Comte himself, to say nothing of the world, should induce us to wish that both his name and his works were buried in oblivion. Now, truly, that Mr. Huxley (the "call" being for the moment his) has so pronounced himself, especially as the facts of the case are exactly and absolutely what he indicates, perhaps we may expect this consummation not to be so very long delayed. More than those members of the revulsion already mentioned, one is apt to suspect, will be anxious now to beat a retreat. Not that this, however, is so certain to be allowed them; for their estimate of M. Comte is a valuable element in the estimate of themselves.

Frankness on the part of Mr. Huxley is not limited to his opinion of M. Comte; it accompanies us throughout his whole essay. He seems even to take pride, indeed, in naming always and everywhere his object at the plainest. That object, in a general point of view, relates, he tells us, solely to materialism, but with a double issue. While it is his declared purpose, in the first place, namely, to lead us into materialism, it is equally his declared purpose, in the second place, to lead us out of materialism. On the first issue, for

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example, he directly warns his audience that to accept the conclusions which he conceives himself to have established on Protoplasm, is to accept these also: That "all vital action" is but "the result of the molecular forces" of the physical basis ; and that, by consequence, to use his own words to his audience, "the thoughts to which I am now giving utterance, and your thoughts regarding them, are but the expression of molecular changes in that matter of life which is the source of our other vital phenomena." And, so far, I think, we shall not disagree with Mr. Huxley when he says that "most undoubtedly the terms of his propositions are distinctly materialistic." Still, on the second issue, Mr. Huxley asserts that he is "individually no materialist." "On the contrary, he believes materialism to involve grave philosophical error;" and the "union of materialistic terminology with the repudiation of materialistic philosophy" he conceives himself to share "with some of the most thoughtful men with whom he is acquainted." In short, to unite both issues, we have it in Mr. Huxley's own words, that it is the single object of his essay "to explain how such a union is not only consistent with, but necessitated by, sound logic;" and that, accordingly, he will, in the first place, "lead us through the territory of vital phenomena to the materialistic slough," while pointing out, in the second, "the sole path by which, in his judgment, extrication is possible." Mr. Huxley's essay, then, falls evidently into two parts ; and of these two parts we may say, further, that while the one—that in which he leads us into materialism—will be predominatingly physiological, the other—or that in which he leads us out of materialism—will be predominatingly philosophical.

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Two corresponding parts would thus seem to be prescribed to any full discussion of the essay; and of these, in the present needs of the world, it is evidently the latter that has the more promising theme. The truth is, however, that Mr. Huxley, after having exerted all his strength in his first part to throw us into "the materialistic slough," by *clear necessity of knowledge*, only calls to us, in his second part, to come out of this slough again, on the somewhat *obscure necessity of ignorance*. This, then, is but a lop-sided balance, where a scale in the air only seems to struggle vainly to raise its well-weighted fellow on the ground. Mr. Huxley, in fact, possesses no remedy for materialism but what lies in the expression that, while he knows not what matter is in itself, he certainly knows that casualty is but contingent succession; and thus, like the so-called "philosophy" of the Revulsion, Mr. Huxley would only mock us into the intensest dogmatism on the one side by a fallacious reference to the intensest scepticism on the other.

The present paper, then, will regard mainly Mr. Huxley's argument *for* materialism, but say what is required, at the same time, on his alleged argument—which is merely the imaginary, or imaginative, impregnation of ignorance—*against* it.

Following Mr. Huxley's own steps in his essay, the course of his positions will be found to run, in summary, thus:—

What is meant by the physical basis of life is, that there is one kind of matter common to all living beings, and it is named protoplasm. No doubt it may appear at first sight that, in the various kinds of living beings, we have only *difference* before us, as in the lichen on the



rock and the painter that paints it,—the microscopic animalcule or fungus and the Finner whale or Indian fig,—the flower in the hair of a girl and the blood in her veins, etc. Nevertheless, throughout these and all other diversities, there really exists a threefold *unity*—a unity of faculty, a unity of form, and a unity of substance.

On the first head, for example, or as regards faculty, power, the action exhibited, there are but three categories of *human* activity—contractility, alimentation, and reproduction ; and there are no fewer for the *lower forms* of life, whether animal or vegetable. In the nettle, for instance, we find the woody case of its sting lined by a granulated, semi-fluid layer, that is possessed of contractility. But in this respect—that is, in the possession of contractile substance—other plants are as the nettle, and all animals are as plants. Protoplasm—for the nettle-layer alluded to is protoplasm—is common to the whole of them. The difference, in short between the powers of the lowest plant or animal and those of the highest is one only of degree and not of kind.

But, on the second head, it is not otherwise in form, or manifested external appearance and structure. Not the sting only, but the whole nettle, is made up of protoplasm ; and of all the other vegetables the nettle is but a type. Nor are animals different. The colorless blood-corpuscles in man and the rest are identical with the protoplasm of the nettle ; and both he and they consisted at first only of an aggregation of such. Protoplasm is the common constituent—the common origin. At last, as at first, all that lives, and every part of all that lives, are but nucleated or unnucleated, modified or unmodified, protoplasm.

But, on the third head, or with reference to unity of

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substance, to internal composition, chemistry establishes this also. All forms of protoplasm, that is, consist alike of carbon, hydrogen, oxygen, and nitrogen, and behave similarly under similar reagents.

So, now, a uniform character having in this threefold manner been proved for protoplasm, what is its origin, and what its fate? Of these the latter is not far to seek. The fate of protoplasm is death—death into its chemical constituents; and this determines its origin also. Protoplasm can originate only in that into which it dies,—the elements—the carbon, hydrogen, oxygen, and nitrogen—of which it was found to consist. Hydrogen, with oxygen, forms water; carbon, with oxygen, carbonic acid; and hydrogen, with nitrogen, ammonia. Similarly, water, carbonic acid and ammonia form, in union, protoplasm. The influence of pre-existing protoplasm only determines combination in *its* case, as that of the electric spark determines combination in the case of water. Protoplasm, then, is but an aggregate of physical materials, exhibiting in combination—only as was to be expected—new properties. The properties of water are not more different from those of hydrogen and oxygen than the properties of protoplasm are different from those of water, carbonic acid, and ammonia. We have the same warrant to attribute the consequences to the premises in the one case as in the other. If, on the first stage of combination, represented by that of water, *simples* could unite into something so different from themselves, why, on the second stage of combination, represented by that of protoplasm, should not *compounds* similarly unite into something equally different from themselves? If the constituents are credited with the properties *there*, why

refuse to credit the constituents with the properties *here?* To the constituents of protoplasm, in truth, any new element, named vitality, has no more been added, than to the constituents of water any new element, named aquosity. Nor is there any logical halting-place between this conclusion and the further and final one: That all vital action whatever, intellectual included, is but the result of the molecular forces of the protoplasm which displays it.

These sentences will be acknowledged, I think, fairly to represent Mr. Huxley's relative deliverances, and, consequently, as I may be allowed to explain again, the only important—while much the larger—part of the whole essay. Mr. Huxley, that is, while devoting fifty paragraphs to our physiological immersion in the “materialistic slough,” grants but one-and-twenty towards our philosophical escape from it; the fifty besides being, so to speak, in reality the wind, and the one-and-twenty only the whistle for it. What these latter say, in effect, is no more than this, that,—matter being known not in itself but only in its qualities, and cause and effect not in their nexus but only in their sequence,—matter may be spirit or spirit matter, cause effect or effect cause—in short, for aught that Mr. Huxley more than phenomenally knows, this may be that or that this, first second, or second first, but the conclusion shall be this, that he will lay out all our knowledge materially, and we may lay out all our ignorance immaterially—if we will. Which reasoning and conclusion, I may merely remark, come precisely to this: That Mr. Huxley—who, hoping yet to see each object (a pin, say) not in its qualities but in *itself*, still, consistently antithetic, cannot believe in the extinction of fire by water or of life by the rope,

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for any *reason* or for any *necessity* that lies in the nature of the case, but simply for the habit of the thing—has not yet put himself at home with the metaphysical categories of *substance* and *casualty*; thanks, perhaps, to those guides of his whom we, the amusing Britons that we are, bravely proclaim “the foremost thinkers of the day”!

The matter and manner of the whole essay are now fairly before us, and I think that, with the approbation of the reader, its procedure, generally, may be described as an attempt to establish, not by any complete and systematic induction, but by a variety of partial and illustrative assertions, two propositions. Of these propositions the first is, That all animal and vegetable organisms are essentially alike in power, in form, and in substance; and the second, That all vital and intellectual functions are the properties of the molecular disposition and changes of the material basis (protoplasm) of which the various animals and vegetables consist. In both propositions, the agent of proof is this same alleged material basis of life, or protoplasm. For the first of them, all animal and vegetable organisms shall be identified in protoplasm; and for the second, a simple chemical analogy shall assign intellect and vitality to the molecular constituents of the protoplasm, in connection with which they are at least exhibited.

In order, then, to obtain a footing on the ground offered us, the first question we naturally put is, What is Protoplasm? And an answer to this question can be obtained only by a reference to the historical progress of the physiological cell theory.

That theory may be said to have wholly grown up

since John Hunter wrote his celebrated work 'On the Nature of the Blood,' etc. New growths, to Hunter depended on an exudation of the plasma of the blood in which, by virtue of its own *plasticity*, vessels formed and conditioned the further progress. The influence of these ideas seems to have still acted, even after a conception of the cell was arrived at. For starting element, Schleiden required an intracellular plasma, and Schwann a structureless exudation, in which minute granules, if not indeed already pre-existent, formed, and by aggregation grew into nuclei, round which singly the production of a membrane at length enclosed a cell. It was then that, in this connection, we heard of the terms blastema and cyto-blastema. The theory of the vegetable cell was completed earlier than that of the animal one. Completion of this latter, again, seems to have been first effected by Schwann, after Müller had insisted on the analogy between animal and vegetable tissue, and Valentin had demonstrated a nucleus in the animal cell, as previously Brown in the vegetable one. But assuming Schwann's labor, and what surrounded it, to have been a first stage, the wonderful ability of Virchow may be said to have raised the theory of the cell fully to a second stage. Now, of this second stage, it is the dissolution or resolution that has led to the emergence of the word Protoplasm.

The body, to Virchow, constituted a free state of individual subjects, with equal rights but unequal capacities. These were the cells, which consisted each of an enclosing membrane, and an enclosed nucleus with surrounding intracellular matrix or matter. These cells, further, propagated themselves, chiefly by partition or division ; and the fundamental principle of the whole

theory was expressed in the dictum, "*Omnis cellula e cellula*." That is, the nucleus, becoming gradually elongated, at last parted in the midst ; and each half, acting as center of attraction to the surrounding intracellular matrix or contained matter, stood forth as a new nucleus to a new cell, formed by division at length of the original cell.

The first step taken in resolution of this theory was completed by Max Schultze, preceded by Leydig. This was the elimination of an investing membrane. Such membrane may, and does, ultimately form ; but in the first instance, it appears, the cell is naked. The second step in the resolution belongs perhaps to Brücke, though preceded by Bergmann, and though Max Schultze, Kühne, Hæckel, and others ought to be mentioned in the same connection. This step was the elimination, or at least subordination, of the nucleus. The nucleus, we are to understand now, is necessary neither to the division nor to the existence of the cell.

Thus, then, stripped of its membrane, relieved of its nucleus, what now remains for the cell? Why, nothing but what *was* the contained matter, the intracellular matrix, and *is*—Protoplasm.

In the application of this word itself, however, to the element in question, there are also a step or two to be noticed. The first step was Dujardin's discovery of sarcode ; and the second the introduction of the term protoplasm as the name for the layer of the *vegetable* cell that lined the cellulose, and enclosed the nucleus. Sarcode, found in certain of the lower forms of life, was a simple substance that exhibited powers of spontaneous contraction and movement. Thus, processes of such simple, soft, contractile matter are protruded by the

rhizopods, and locomotion by their means effected. Remak first extended the use of the term *protoplasm* from the layer which bore that name in the vegetable cell to the analogous element in the animal cell ; but it was Max Schultze, in particular, who, by applying the name to the intracellular matrix, or contained matter, when divested of membrane, and by identifying this substance itself with sarcode, first fairly established *protoplasm*, name and thing, in its present prominence.

In this account I have necessarily omitted many subordinate and intervening steps in the successive establishment of the *contractility*, superior *importance*, and complete *isolation* of this thing to which, under the name of *protoplasm*, Mr. Huxley of late has called such vast attention. Besides the names mentioned, there are others of great eminence in this connection, such as Meyen, Siebold, Reichert, Ecker, Henle, and Kölliker among the Germans ; and among ourselves, Beale and Huxley himself. John Goodsir will be mentioned again.

We have now, perhaps, obtained a general idea of *protoplasm*. Brücke, when he talks of it as "living cell-body or elementary organism," comes very near the leading idea of Mr. Huxley as expressed in his phrase, "the physiological basis, or matter, of life." Living cell-body, elementary organism, primitive living matter—that, evidently, is the quest of Mr. Huxley. There is aqueous matter, he would say, perhaps, composed of hydrogen and oxygen, and it is the same thing whether in the rain-drop or the ocean ; so, similarly, there is vital matter, which, composed of carbon, hydrogen, oxygen, and nitrogen, is the same thing whether in cryptogams or in elephants, in animalcules or in men. What,

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in fact, Mr. Huxley seeks, probably, is living protein—protein, so to speak, struck into life. Just such appears to him to be the nature of protoplasm, and in it he believes himself to possess at last *a living clay* wherewith to build the whole organic world.

The question, What is Protoplasm? is answered, then ; but, for the understanding of what is to follow, there is still one general consideration to be premised.

Mr. Huxley's conception of protoplasm, as we have seen, is that of living matter, living protein ; what we may call, perhaps, elementary life-stuff. Now, is it quite certain that Mr. Huxley is correct in this conception? Are we to understand, for example, that cells have now definitively vanished, and left in their place only a uniform and universal *matter* of quite indefinite proportions? No ; such an understanding would be quite wrong. Whatever may be the opinion of the adherents of the molecular theory of generation, it is certain that all the great German histologists still hold by the cell, and can hardly open their mouths without mention of it. I do not allude here to any special adherents of either nucleus or membrane, but to the most advanced innovators in both respects ; to such men as Schultze and Brücke and Kühne. These, as we have seen, pretty well confine their attention, like Mr. Huxley, to the protoplasm. But they do not the less on that account talk of the cell. For them, it is only in cells that protoplasm exists. To their view, we cannot fancy protoplasm as so much matter in a pot, in an ointment-box, any portion of which scooped out in an ear-picker would be so much life-stuff, and, though a part, quite as good as the whole. This seems to be Mr. Huxley's conception, but it is not theirs. A certain

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*measure* goes with protoplasm to constitute it an organism to them, and worthy of their attention. They refuse to give consideration to any mere protoplasm-*shred* that may not have yet ceased, perhaps, to exhibit all sign of contractility under the microscope, and demand a protoplasm-*cell*. In short, protoplasm is to them still distributed into cells, and only that measure of protoplasm is cell that is adequate to the whole group of vital manifestations. Brücke, for example, of all innovators probably the most innovating, and denying, or inclined to deny, both nucleus and membrane, does not hesitate, according to Stricker, to speak still of cells as self-complete organisms, that move and grow, that nourish and reproduce themselves, and that perform specific function. "Omnis cellula e cellulâ," is the rubric they work under as much now as ever. The heart of a turtle, they say, is not a turtle ; so neither is a protoplasm-shred a protoplasm-cell.

This, then, is the general consideration which I think it necessary to premise ; and it seems, almost of itself, to negate Mr. Huxley's reasonings in advance, for it warrants us in denying that physiological clay of which all living things are but bricks baked, Mr. Huxley intimates, and in establishing in its place cells as before—living cells that differ infinitely the one from the other, and so differ from the very first moment of their existence. This consideration shall not be allowed to pre-empt, however, an examination of Mr. Huxley's own proofs, which will only the more and more avail to indicate the difference suggested.

These proofs, as has been said, would, by means of the single fulcrum of protoplasm, establish, first, the identity, and, second, the materiality, of all vegetable

and animal life. These are, shortly, the two propositions which we have already seen, and to which, in their order, we now pass.

All organisms, then, whether animal or vegetable, have been understood for some time back to originate in and consist of cells ; but the progress of physiology has *seemed* now to substitute for cells a single matter of life, protoplasm ; and it is here that Mr. Huxley sees his cue. Mr. Huxley's very first word is the "physical basis or matter of life ;" and he supposes "that to many the idea that there is such a thing may be novel." This, then, so far, is what is *new* in Mr. Huxley's contribution. He seems to have said to himself, if formerly the whole world was thought kin in an "ideal" or formal element, organization, I shall now finally complete this identification in a "physical" or material element, protoplasm. In short, what at this stage we are asked to witness in the essay is, the identification of all living beings whatever in the identity of protoplasm. As there is a single matter, clay, which is the matter of all bricks, so there is a single matter, protoplasm, which is the matter of all organisms. "Protoplasm is the clay of the potter, which, bake it and paint it as he will, remains clay, separated by artifice, and not by nature, from the commonest brick or sun-dried clod." Now here I cannot help stopping a moment to remark that Mr. Huxley puts emphatically his whole soul into this sentence, and evidently believes it to be, if we may use the word, a *clincher*. But, after all, does it say much? or rather, does it say anything? To the question, "Of what are you made?" the answer, for a long time now, and by the great mass of human-beings who are supposed civilized, has been "Dust." Dust, and the same dust, has

been allowed to constitute us all. But materialism has not on that account been the irresistible result. Attention hitherto—and surely excusably, or even laudably in such a case—has been given not so much to the dust as to the “potter,” and the “artifice” by which he could so transform, or, as Mr. Huxley will have it, *modify* it. To ask us to say, instead of dust, clay, or even protoplasm, is not to ask us for much, then, seeing that even to Mr. Huxley there still remain both the “potter” and his “artifice.”

But to return: To Mr. Huxley, when he says all bricks, being made of clay, are the same thing, we answer, Yes, undoubtedly, if they are made of the same clay. That is, the bricks are identical if the clay is identical; but, on the other hand, by as much as the clay differs will the bricks differ. And, similarly, all organisms can be identified only if their composing protoplasm can be identified. To this stake is the argument of Mr. Huxley bound.

This argument itself takes, as we have seen, a three-fold course: Mr. Huxley will prove his position in this place by reference, firstly, to unity of faculty; secondly, to unity of form; and thirdly, to unity of substance. It is this course of proof, then, which we have now to follow, but taking the question of substance, as simplest, first, and the others later.

By substance, Mr. Huxley understands the internal or chemical composition; and, with a mere reference to the action of reagents, he asserts the protoplasm of all living beings to be an identical combination of carbon, hydrogen, oxygen, and nitrogen. It is for us to ask, then, Are all samples of protoplasm identical, first, in their chemical composition, and, second, under the action of the various reagents?

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On the first clause, we may say, in the first place, towards a proof of difference which will only cumulate, I hope, that, even should we grant in all protoplasm an identity of chemical ingredients, what is called *Allotropy* may still have introduced no inconsiderable variety. Ozone is not antozone, nor is oxygen either, though in chemical constitution all are alike. In the second place, again, we may say that, with *varying proportions*, the same component parts produce very various results. By way of illustration, it will suffice to refer to such different things as the proteids, gluten, albumen, fibrin, gelatine, etc., compared with the urinary products, urea and uric acid ; or with the biliary products, glyocol, glycolic acid, bili-rubin, bili-verdin, etc. ; and yet all these substances, varying so much the one from the other, are, as protoplasm is, compounds of carbon, hydrogen, oxygen, and nitrogen. But, in the third place, we are not limited to a *may say* ; we can assert the fact that all protoplasm is not chemically identical. All the tissues of the organism are called protoplasm by Mr. Huxley ; but can we predicate chemical identity of muscle and bone, for example ? In such cases Mr. Huxley, it is true, may bring the word "modified" into use ; but the objection of modification we shall examine later. In the mean time, we are justified, by Mr. Huxley's very argument, in regarding all organized tissues whatever as protoplasm ; for if these tissues are not to be identified in protoplasm, we must suppose denied what it was his one business to affirm. And it is against that affirmation that we point to the fact of much chemical difference obtaining among the tissues, not only in the *proportions* of their fundamental elements, but also in the *addition* (and proportions as well)

of such others as chlorine, sulphur, phosphorus, potass, soda, lime, magnesia, iron, etc. Vast differences vitally must be legitimately assumed for tissues that are so different chemically. But, in the fourth place, we have the authority of the Germans for asserting that the cells themselves—and they now, to the most advanced, are only protoplasm—do differ chemically, some being found to contain glycogen, some cholesterine, some protogon, and some myosin. Now such substances, let the chemical analogy be what it may, must still be allowed to introduce chemical difference. In the last place, Mr. Huxley's analysis is an analysis of *dead* protoplasm, and indecisive, consequently, for that which lives. Mr. Huxley betrays sensitiveness in advance to this objection; for he seeks to rise above the sensitiveness and the objection at once by styling the latter "frivolous." Nevertheless the Germans say pointedly that it is unknown whether the same elements are to be referred to the cells after as before death. Kühne does not consider it proved that living muscle contains syntonin; yet Mr. Huxley tells us, in his Physiology, that "syntonin is the chief constituent of muscle and flesh." In general, we may say, according to Stricker, that all weight is put now on the examination of living tissue, and that the difference is fully allowed between that and dead tissue.

On the second clause now, or with regard to the action of reagents, these must be denied to produce the like result on the various forms of protoplasm. With reference to temperature, for example, Kühne reports the movements of the amoeba to be arrested in iced water; while, in the same medium, the ova of the trout furrow famously, but perish even in a warmed room. Others, again, we are told, may be actually dried, and

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yet live. Of ova in general, in this connection, it is said that they live or die according as the temperature to which they are exposed differs little or much from that which is natural to the organisms producing them. In some, according to Max Schultze, even distilled water is enough to arrest movement. Now, not to dwell longer here, both amoeba and ova are to Mr. Huxley pure protoplasm; and such difference of result, according to difference of temperature, etc., must assuredly be allowed to point to a difference of original nature. Any conclusion so far, then, in regard to unity of substance, whether the chemical composition or the action of reagents be considered, cannot be said to bear out the views of Mr. Huxley.

What now of the unities of form and power in protoplasm? By form, Mr. Huxley will be found to mean the general appearance and structure; and by faculty or power, the action exhibited. Now it will be very easy to prove that, in neither respect, do all specimens of protoplasm agree. Mr. Huxley's representative protoplasm, it appears, is that of the nettle-sting; and he describes it as a granulated, semi-fluid body, contractile in mass, and contractile also in detail to the development of a species of circulation. Stricker, again, speaks of it as a homogeneous substance, in which any granules that may appear must be considered of foreign importation, and in which there are no evidences of circulation. In this last respect, then, that Mr. Huxley should talk of "tiny Maelstroms," such as even in the silence of a tropical noon might stun us, if heard, as "with the roar of a great city," may be viewed, perhaps, as a rise into poetry beyond the occasion.

Further, according to Stricker, protoplasm varies al-

most infinitely in consistence, in shape, in structure, and in function. In consistence, it is sometimes so fluid as to be capable of forming in drops ; sometimes semi-fluid and gelatinous ; sometimes of considerable resistance. In shape—for to Stricker the cells are now protoplasm—we have club-shaped protoplasm, globe-shaped protoplasm, cup-shaped protoplasm, bottle-shaped protoplasm, spindle-shaped protoplasm—branched, threaded, ciliated protoplasm, — circle-headed protoplasm—flat, conical, cylindrical, longitudinal, prismatic, polyhedral, and palisade-like protoplasm. In structure, again, it is sometimes uniform and sometimes reticulated into interspaces that contain fluid. In function, lastly—and here we have entered on the consideration of faculty or power—some protoplasm is vagrant (so to translate *wandernd*), and of unknown use, like the colorless blood-corpuscles.

In reference to these, as strengthening the argument, and throwing much light generally, I break off a moment to say that, very interesting as they are in themselves, and as Recklinghausen, in especial, has made them, Mr. Huxley's theory of them disagrees considerably with the prevalent German one. He speaks of them as the source of the body in general, yet, in his Physiology, he talks of the spleen, the lymphatics, and even the liver—*parts* of the body—as *their* source. They are so few in number that, while Mr. Huxley is thankful to be able to point to the inside of the lips as a seat for them, they bear to the red corpuscles only the proportion of 1 to 450. This disproportion, however, is no bar to Mr. Huxley's derivation of the latter from the former. But the fact is questioned. The Germans, generally, for their part, describe the color-

less, or vagrant, blood-corpuscles as probably media of conjugation or reparation, but acknowledge their function to be as yet quite unknown ; while Rindfleisch, characterizing the spleen as the grave of the red, and the womb of the white, corpuscles, evidently refers the latter to the former. This, indeed, is a matter of direct assertion with Preyer, who has " shown that pieces of red blood-corpuscles may be eaten by the amoeboid cells of the frog," and holds that the latter (the white corpuscles) proceed directly from the former (the red corpuscles) ; so that it seems to be determined in the mean time that there is no proof of the reverse being the fact.

In function, then, to resume, some protoplasm is vagrant, and of unknown use. Some again produces pepsine, and some fat. Some at least contains pigment. Then there is nerve-protoplasm, brain-protoplasm, bone-protoplasm, muscle-protoplasm, and protoplasm of all the other tissues, no one of which but produces only its own kind, and is uninterchangeable with the rest. Lastly, on this head, we have to point to the overwhelming fact that there is the infinitely different protoplasm of the various infinitely different plants and animals, in each of which its own protoplasm, as in the case of that of the various tissues, but produces its own kind, and is uninterchangeable with that of the rest.

It may be objected, indeed, that these latter are examples of modified protoplasm. The objection of modification, as said, we have to see by itself later ; but, in the mean time, it may be asked, Where are we to begin, *not* to have modified protoplasm ? We have the example of Mr. Huxley himself, who, in the nettle-



sting, begins already with modified protoplasm ; and we have the authority of Rindfleisch for asserting that "in every different tissue we must look for a different initial term of the productive series." This, evidently, is a very strong light on the original multiplicity of protoplasm, which the consideration, as we have seen, of the various plants and animals, has made, further, infinite. This is enough ; but there is no wish to evade beginning with the very beginning—with absolutely pure initial protoplasm, if it can but be given us in any reference. The simple egg—that, probably is the beginning—that, probably, is the original identity ; yet even there we find already distribution of the identity into infinite difference. This, certainly, with reference to the various organisms, but with reference also to the various tissues. That we regard the egg as the beginning, and that we do not start, like the smaller exceptional physiological school, with molecules themselves, depends on this, that the great Germans so often alluded to, Kühne among them, still trust in the experiments of Pasteur ; and while they do not deny the possibility, or even the fact, of molecular generation, still feel justified in denying the existence of any observation that yet unassailably attests a *generatio æquivoca*. By such authority as this the simple philosophical spectator has no choice but to take his stand ; and therefore it is that I assume the egg as the established beginning, so far, of all vegetable and animal organisms. To the egg, too, as the beginning, Mr. Huxley, though the lining of the nettle-sting is his representative protoplasm, at least refers. "In the earliest condition of the human organism," he says, in allusion to the white (vagrant) corpuscles of the blood, "in that state in

which it has but just become distinguished from the egg in which it arises, it is nothing but an aggregation of such corpuscles, and every organ of the body was once no more than such an aggregation." Now, in beginning with the egg—an absolute beginning being denied us in consequence of the pre-existent infinite difference of the egg or eggs themselves—we may gather from the German physiologists some such account of the actual facts as this.

The first change signalized in the impregnated egg seems that of *Furchung*, or furrowing—what the Germans call the *Furchungskugeln*, the *Dotterkugeln*, form. Then these *Kugeln*—clumps, eminences, monticles, we may translate the word—break into cells; and these are the cells of the embryo. Mr. Huxley, as quoted, refers to the whole body, and every organ of the body, as at first but an aggregation of colorless blood-corpuscles; but in the very statement which would render the identity alone explicit, the difference is quite as plainly implicit. As much as this lies in the word "organs," to say nothing of "human." The cells of the "organs," to which he refers, are even then uninterchangeable, and produce but themselves. The Germans tell us of the *Keimblatt*, the germ-leaf, in which all these organs originate. This *Blatt*, or leaf, is three-fold, it seems; but even these folds are not indifferent. The various cells have their distinct places in them from the first. While what in this connection are called the epithelial and endorthelial tissues spring respectively from the *upper* and *under* leaf, connective tissues, with muscle and blood, spring from the *middle* one. Surely in such facts we have a perfect warrant to assert the initial non-identity of protoplasm, and to insist on this,

that, from the very earliest moment—even literally *ab ovo*—brain-cells only generate brain-cells, bone-cells bone-cells, and so on.

These considerations on function all concern faculty or power ; but we have to notice now that the characteristic and fundamental form of power is to Mr. Huxley *contractility*. He even quotes Goethe in proof of contractility being the main power or faculty of *Man* ! Nevertheless it is to be said at once that, while there are differences in what protoplasm *is* contractile, all protoplasm is not contractile, nor dependent on contractility for its functions. In the former respect, for example, muscle, while it is the contractile tissue special, is also to Mr. Huxley protoplasm ; yet Stricker asserts the inner construction of the contractile substance, of which muscle-fibre virtually consists, to be essentially different from contractile protoplasm. Here, then, we have the contractile *substance* proper “essentially different” from the contractile *source* proper. In the latter respect, again, we shall not call in the *uncontractible* substances which Mr. Huxley himself denominates protoplasm—bread, namely, roast mutton, and boiled lobster ; but we may ask where—even in the case of a living body—is the contractility of white of egg ? In this reference, too, we may remark that Kühne, who divides the protoplasm of the epidermis into three classes, has been unable to distinguish contractility in his own third class. Lastly, where, in relation to the protoplasm of the nervous system, is there evidence of its contractility ? Has any one pretended that thought is but the contraction of the brain ; or is it by contraction that the very nerves operate contraction—the nerves that supply muscles, namely ? Mr. Huxley himself, in

his Physiology, describes nervous action very differently. There *conduction* is spoken of without a hint of contraction. Of the higher faculties of man I have to speak again; but let us just ask where, in the case of any pure sensation—smell, taste, touch, sound, color—is there proof of any contraction? Are we to suppose that between the physical cause of heat without and the mental sensation of heat within, contraction is anywhere interpolated? Generally, in conclusion here, while reminding of Virchow's testimony to the inherent inequalities of cell-capacity, let us but, on the question of faculty, contrast the kidney and the brain, even as these organs are viewed by Mr. Huxley. To him the one is but a sieve for the extrusion of refuse: the other thinks Newton's 'Principia' and Iliads of Homer.

Probably, then, in regard to any continuity in protoplasm of power, of form, or of substance, we have seen *lacune* enow. Nay, Mr. Huxley himself can be adduced in evidence on the same side. Not rarely do we find in his essay admissions of *probability* where it is *certainty* that is alone in place. He says, for example, "It is more than probable that *when* the vegetable world is thoroughly explored we *shall* find all plants in possession of the same powers." When a conclusion is decidedly announced, it is rather disappointing to be told, as here, that the premises are still to collect. "*So far*," he says again, "as the conditions of the manifestations of the phenomena of contractility have *yet* been studied." Now, such a *so far* need not be *very far*; and we may confess in passing, that from Mr. Huxley the phrase, "the conditions of the *manifestations* of the *phenomena*," grates. We hear again that it is "the rule *rather* than the exception," or that "weighty authorities

have *suggested*" that such and such things "probably occur," or, while contemplating the nettle-sting, that such "*possible* complexity" in other cases "*dawns* upon one." On other occasions he expresses himself to the effect that "perhaps it would not yet be safe to say that *all* forms," etc. Nay, not only does he directly *say* that "it is by no means his intention to suggest that there is no difference between the lowest plant and the highest, or between plants and animals," but he directly proves what he says, for he demonstrates in plants and animals an *essential difference of power*. Plants *can* assimilate inorganic matters, animals *can not*, etc. Again, here is a passage in which he is seen to cut his own "*basis*" from beneath his own feet. After telling us that all forms of protoplasm consist of carbon, hydrogen, oxygen, and nitrogen "in very complex union," he continues, "To this complex combination, *the nature of which has never been determined with exactness*, the name of protein has been applied." This, plainly, is an identification, on Mr. Huxley's own part, of protoplasm and protein; and what is said of the one being necessarily true of the other, it follows that Mr. Huxley admits the nature of protoplasm never to have been determined with exactness, and that, even in his eyes, the *lis* is still *sub judice*. This admission is strengthened by the words, too, "If we use this term" (protein) "with such *caution* as may properly arise out of our *comparative ignorance* of the things for which it stands;" which entitle us to recommend, in consequence "of our comparative ignorance of the things for which it stands," "*caution*" in the use of the term protoplasm. In such a state of the case we cannot wonder that Mr. Huxley's own conclusion here is: Therefore "all living

matter is more or less albuminoid." All living matter is more or less albuminoid ! That, indeed, is the single conclusion of Mr. Huxley's whole industry ; but it is a conclusion that, far from requiring the intervention of protoplasm, had been reached long before the word itself had been, in this connection, used.

It is in this way, then, that Mr. Huxley can be aduced in refutation of himself ; and I think his resort to an epigram of Goethe's for reduction of the powers of man to those of contraction, digestion, and reproduction, can be regarded as an admission to the same effect. The epigram runs thus :—

"Warum treibtsich das Volk so, und schreit ? Es will sich ernähren,  
Kinder zeugen, und die nähren so gut es vermag.

Weiter bringt es kein Mensch, stell' er sich wie er auch will."

That means, quite literally translated, "Why do the folks bustle and bawl ? They want to feed themselves, get children, and then feed them as best they can ; no man does more, let him do as he may." This, really, is Mr. Huxley's sole proof for his classification of the powers of man. Is it sufficient ? Does it not apply rather to the birds of the air, the fish of the sea, and the beasts of the field, than to man ? Did Newton only feed himself, beget children, and then feed them ? Was it impossible for him to do any more, let him do as he might ? And what we ask of Newton we may ask of all the rest. To elevate, therefore, the passing whim of mere literary *Laune* into a cosmical axiom and a proof in place—this we cannot help adding to the other productions here in which Mr. Huxley appears against himself.

But were it impossible either for him or us to point to these *lacunæ*, it would still be our right and our duty

to refer to the present conditions of microscopic science in general as well as in particular, and to demur to the erection of its *dicta*, constituted as they yet are, into established columns and buttresses in support of any theory of life, material or other.

The most delicate and dubious of all the sciences, it is also the youngest. In its manipulations the slightest change may operate as a destructive drought, or an equally destructive deluge. Its very tools may positively create the structure it actually examines. The present state of the science, and what warrant it gives Mr. Huxley to dogmatize on protoplasm, we may understand from this avowal of Kühne's: "To-day we believe that we see" such or such fact, "but know not that further improvements in the means of observation will not reveal what is assumed for certainty to be only illusion." With such authority to lean on—and it is the highest we can have—we may be allowed to entertain the conjecture, that it is just possible that some certainties, even of Mr. Huxley, may yet reveal themselves as illusions.

But, in resistance to any sweeping conclusions built on it, we are not confined to a reference to the imperfections involved in the very nature and epoch of the science itself in general. With yet greater assurance of carrying conviction with us, we may point in particular to the actual opinions of its present professors. We have seen already, in the consideration premised, that Mr. Huxley's hypothesis of a protoplasm *matter* is unsupported, even by the most innovating Germans, who as yet will not advance, the most advanced of them, beyond a protoplasm-cell; and that his whole argument is thus sapped in advance. But what threatens more

absolute extinction of this argument still, *all* the German physiologists do *not* accept even the protoplasm-cell. Rindfleisch, for example, in his recently-published 'Lehrbuch der pathologischen Gewebelehre,' speaks of the cell very much as we understand Virchow to have spoken of it. To him there is in the cell not only protoplasm but nucleus, and perhaps membrane as well. To him, too, the cell propagates itself, quite as we have been hitherto fancying it to do, by division of the nucleus, increase of the protoplasm, and ultimate partition of the cell itself. Yet he knows withal of the opinions of others, and accepts them in a manner. He mentions Kühne's account of the membrane as at first but a mere physical limit of two fluids—a mere peripheral film or curdling; still he assumes a formal and decided membrane at last. Even Leydig and Schultze, who shall be the express eliminators of the membrane—the one by initiation and the other by consummation—confess that, as regards the cells of certain tissues, they have never been able to detect in them the absence of a membrane.

As regards the nucleus again, the case is very much stronger. When we have admitted with Brücke that certain cryptogam cells, with Haeckel that certain protists, with Cienkowsky that two monads, and with Schultze that one amoeba, are without nucleus—when we have admitted that division of the cell *may* take place without implicating that of the nucleus—that the movements of the nucleus *may* be passive and due to those of the protoplasm—that Baer and Stricker demonstrate the disappearance of the original nucleus in the impregnated egg,—when we have admitted this, we have admitted also all that can be said in degradation



of the nucleus. Even those who say all this still attribute to the nucleus an important and unknown rôle, and describe the formation in the impregnated egg of a new nucleus ; while there are others again who resist every attempt to degrade it. Böttcher asserts movement for the nucleus, even when wholly removed from the cell ; Neumann points to such movement in dead or dying cells ; and there is other testimony to a like effect, as well as to peculiarities of the nucleus otherwise that indicate spontaneity. In this reference we may allude to the weighty opinion of the late Professor Goodsir, who anticipated in so remarkable a manner certain of the determinations of Virchow. Goodsir, in that anticipation, wonderfully rich and ingenious as he is everywhere, is perhaps nowhere more interesting and successful than in what concerns the nucleus. Of the whole cell, the nucleus is to him, as it was to Schleiden, Schwann, and others, the most important element. And this is the view to which I, who have little business to speak, wish success. This universe is not an accidental cavity, in which an accidental dust has been accidentally swept into heaps for the accidental evolution of the majestic spectacle of organic and inorganic life. That majestic spectacle is a spectacle as plainly for the eye of reason as any diagram of the mathematician. That majestic spectacle could have been constructed, was constructed, only in reason, for reason, and by reason. From beyond Orion and the Pleiades, across the green hem of earth, up to the imperial personality of man, all, the furthest, the dearest, the dustiest, is for fusion in the invisible point of the single Ego—which alone glorifies it. For the subject, and on the model of the subject, all is made. Therefore it is

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that—though, precisely as there are acephalous monsters by way of exception and deformity, there may be also at the very extremity of animated existence cells without a nucleus—I cannot help believing that this nucleus itself, as analogue of the subject will yet be proved the most important and indispensable of all the normal cell-elements. Even the phenomena of the impregnated egg seem to me to support this view. In the egg, on impregnation, it seems to me natural (I say it with a smile) that the old sun that ruled it should go down, and that a new sun, stronger in the combination of the new and the old, should ascend into its place !

Be these things as they may, we have now overwhelming evidence before us for concluding, with reference to Mr. Huxley's first proposition, that—in view of the nature of microscopic science—in view of the state of belief that obtains at present as regards nucleus, membrane, and entire cell—even in view of the supporters of protoplasm itself—Mr. Huxley is not authorized to speak of a physical matter of life ; which, for the rest, if granted, would, for innumerable and, as it appears to me, irrefragable reasons, be obliged to acknowledge for itself, not identity, but an infinite diversity in power, in form and in substance.

So much for the first proposition in Mr. Huxley's essay, or that which concerns protoplasm, as a supposed matter of life, identical itself, and involving the identity of all the various organs and organisms which it is assumed to compose. What now of the second proposition, or that which concerns the materiality at once of protoplasm, and of all that is conceived to derive from protoplasm ? In other words, though, so to speak, for organic bricks anything like an organic clay still awaits

the proof, I ask, if the bricks are not the same because the clay is not the same, what if the materiality of the former is equally unsupported by the materiality of the latter? Or what if the functions of protoplasm are not properties of its mere molecular constitution?

For this is Mr. Huxley's second proposition, namely, That all vital and intellectual functions are but the properties of the molecular disposition and changes of the material basis (protoplasm) of which the various animals and vegetables consist. With the conclusions now before us, it is evident that to enter at all on this part of Mr. Huxley's argumentation is, so far as we are concerned, only a matter of grace. In order that it should have any weight, we must grant the fact, at once of the existence of a matter of life, and of all organs and organisms being but aggregates of it. This, obviously, we cannot now do. By way of hypothesis, however, we may assume it. Let it be granted, then, that *pro hac vice* there is a physical basis of life with all the consequences named; and now let us see how Mr. Huxley proceeds to establish its materiality.

The whole former part of Mr. Huxley's essay consists (as said) of fifty paragraphs, and the argument immediately concerned is confined to the latter ten of them. This argument is the simple chemical analogy that, under stimulus of an electric spark, hydrogen and oxygen uniting into an equivalent weight of water, and, under stimulus of preëxisting protoplasm, carbon, hydrogen, oxygen, and nitrogen uniting into an equivalent weight of protoplasm, there is the same warrant for attributing the properties of the consequent to the properties of the antecedents in the latter case as in the former. The properties of protoplasm are, in origin and charac-

ter, precisely on the same level as the properties of water. The cases are perfectly parallel. It is as absurd to attribute a new entity vitality to protoplasm, as a new entity aqueosity to water. Or, if it is by its mere chemical and physical structure that water exhibits certain properties called aqueous, it is also by its mere chemical and physical structure that protoplasm exhibits certain properties called vital. All that is necessary in either case is, "under certain conditions," to bring the chemical constituents together. If water is a molecular complication, protoplasm is equally a molecular complication, and for the description of the one or the other there is no change of language required. A new substance with new qualities results in precisely the same way here, as a new substance with new qualities there; and the derivative qualities are not more different from the primitive qualities in the one instance, than the derivative qualities are different from the primitive qualities in the other. Lastly, the *modus operandi* of preëxistent protoplasm is not more unintelligible than that of the electric spark. The conclusion is irresistible, then, that all protoplasm being reciprocally convertible, and consequently identical, the properties it displays, vitality and intellect included, are as much the result of molecular constitution as those of water itself.

It is evident, then, that the fulcrum on which Mr. Huxley's second proposition rests, is a single inference from a chemical analogy. Analogy, however, being never identity, is apt to betray. The difference it hides may be essential, that is, while the likeness it shows may be inessential—so far as the conclusion is concerned. That this mischance has overtaken Mr. Hux-

ley here, it will, I fancy, not be difficult to demonstrate.

The analogy to which Mr. Huxley trusts has two references: one, to chemical composition, and one to a certain stimulus that determines it. As regards chemical composition, we are asked, by virtue of the analogy obtaining, to identify, as equally simple instances of it, protoplasm here and water there; and, as regards the stimulus in question, we are asked to admit the action of the electric spark in the one case to be quite analogous to the action of preëxisting protoplasm in the other. In both references I shall endeavor to point out that the analogy fails; or, as we may say it also, that, even to Mr. Huxley, it can only seem to succeed by discounting the elements of difference that still subsist.

To begin with chemical combination, it is not unjust to demand that the analogy which must be admitted to exist in that, and a general physical respect, should not be strained beyond its legitimate limits. Protoplasm cannot be denied to be a chemical substance; protoplasm cannot be denied to be a physical substance. As a compound of carbon, hydrogen, oxygen and nitrogen, it comports itself chemically—at least in ultimate instance—in a manner not essentially different from that in which water, as a compound of hydrogen and oxygen, comports itself chemically. In mere physical aspect, again, it may count quality for quality with water in the same aspect. In short, so far as it is on chemical and physical structure that the possession of distinctive properties in any case depends, both bodies may be allowed to be pretty well on a par. The analogy must be allowed to hold so far: so far but no farther. One step farther and we see not only that

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protoplasm has, like water, a chemical and physical structure ; but that, unlike water, it has also an organized or organic structure. Now this, on the part of protoplasm, is a possession in excess ; and with relation to that excess there can be no grounds for analogy. This, perhaps, is what Mr. Huxley has omitted to consider. When insisting on attributing to protoplasm the qualities it possessed, because of its chemical and physical structure, if it was for chemical and physical structure that we attributed to water *its* qualities, he has simply forgotten the addition to protoplasm of a third structure that can only be named organic. "If the phenomena exhibited by water are its properties, so are those presented by protoplasm, living or dead, its properties." When Mr. Huxley speaks thus, Exactly so, we may answer : "living or dead !" That alternative is simply slipped in and passed ; but it is in that alternative that the whole matter lies. Chemically, dead protoplasm is to Mr. Huxley quite as good as living protoplasm. As a sample of the article, he is quite content with dead protoplasm, and even swallows it, he says, in the shape of bread, lobster, mutton, etc., with all the satisfactory results to be desired. Still, as concerns the argument, it must be pointed out that it is only these that can be placed on the same level as water ; and that living protoplasm is not only unlike water, but it is unlike dead protoplasm. Living protoplasm, namely, is identical with dead protoplasm only so far as its chemistry is concerned (if even so much as that) ; and it is quite evident, consequently, that difference between the two cannot depend on that in which they are identical—cannot depend on the chemistry. Life, then, is no affair of chemical and physical structure, and must

find its explanation in something else. It is thus that, lifted high enough, the light of the analogy between water and protoplasm is seen to go out. Water, in fact, when formed from hydrogen and oxygen, is, in a certain way and in relation to them, no new product ; it has still, like them, only chemical and physical qualities ; it is still, as they are, inorganic. So far as *kind* of power is concerned, they are still on the same level. But not so protoplasm, where, with preservation of the chemical and physical likeness there is the addition of the unlikeness of life, of organization, and of ideas. But the addition is a new world—a new and higher world, the world of a self-realizing thought, the world of an *entelechy*. The change of language objected to by Mr. Huxley is thus a matter of necessity, for it is *not* mere molecular complication that we have any longer before us, and the qualities of the derivative are essentially and absolutely different from the qualities of the primitive. If we did invent the term aquosity, then, as an abstract sign for all the qualities of water, we should really do very little harm ; but aquosity and vitality would still remain essentially unlike. While for the invention of aquosity there is little or no call, however, the fact in the other case is that we are not only compelled to invent, but to *perceive* vitality. We are quite willing to do as Mr. Huxley would have us to do : look on, watch the phenomena, and name the results. But just in proportion to our faithfulness in these respects is the necessity for the recognition of a new world and a new nomenclature. There are certainly different states of water, as ice and steam ; but the relation of the solid to the liquid, or of either to the vapor, surely offers no analogy to the relation of proto-

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plasm dead to protoplasm alive. That relation is not an analogy but an antithesis, the antithesis of antitheses. In it, in fact, we are in presence of the one incommunicable gulf—the gulf of all gulfs—that gulf which Mr. Huxley's protoplasm is as powerless to efface as any other material expedient that has ever been suggested since the eyes of men first looked into it—the mighty gulf between death and life.

The differences alluded to (they are, in order, organization and life, the objective idea—design, and the subjective idea—thought), it may be remarked, are admitted by those very Germans to whom protoplasm, name and thing, is due. They, the most advanced and innovating of them, directly avow that there is present in the cell "an architectonic principle that has not yet been detected." In pronouncing protoplasm capable of active or vital movements, they do by that refer, they admit also, to an immaterial force, and they ascribe the processes exhibited by protoplasm—in so many words—not to the molecules, but to organization and life. It is remarked by Kant that "the reason of the specific mode of existence of every part of a living body lies in the whole, whilst with dead masses each part bears this reason within itself;" and this indeed is how the two worlds are differentiated. A drop of water, once formed, is there passive for ever, susceptible to influence, but indifferent to influence, and what influence reaches it is wholly from without. It may be added to, it may be subtracted from; but infinitely apathetic quantitatively, it is qualitatively independent. It is indifferent to its own physical parts. It is without contractility, without alimentation, without reproduction, without specific function. Not so the cell, in which the



parts are dependent on the whole, and the whole on the parts ; which has its activity and *raison d'être* within ; which manifests all the powers which we have described water to want ; and which requires for its continuance conditions of which water is independent. It is only so far as organization and life are concerned, however, that the cell is thus different from water. Chemically and physically, as said, it can show with it quality for quality. How strangely Mr. Huxley's deliverances show beside these facts ! He can " see no break in the series of steps in molecular complication ;" but, glaringly obvious, there is a step added that is not molecular at all, and that has its supporting conditions completely elsewhere. The molecules are as fully accounted for in protoplasm as in water ; but the sum of qualities, thus exhausted in the latter, is not so exhausted in the former, in which there are qualities due, plainly, not to the molecules as molecules, but to the form into which they are thrown, and the force that makes that form one. When the chemical elements are brought together, Mr. Huxley says, protoplasm is formed, " and this protoplasm exhibits the phenomena of life ;" but he ought to have added that these phenomena are themselves added to the phenomena for which all that relates to chemistry stands, and are there, consequently, only by reason of some other determinant. New consequents necessarily demand new antecedents. " We think fit to call different kinds of matter carbon, oxygen, hydrogen, and nitrogen, and to speak of the various powers and activities of these substances as the properties of the matter of which they are composed." That, doubtless, is true, we say ; but such statements do not exhaust the facts. We call water hydrogen and oxygen,

and attribute *its* properties to the properties of them. In a chemical point of view, we ought to do the same thing for ice and steam ; yet, for all the chemical identity, water is not ice, nor is either steam. Do we, then, in these cases, make nothing of the *difference*, and in its despite enjoy the satisfaction of viewing the three as one? Not so ; we ask a reason for the difference ; we demand an antecedent that shall render the consequent intelligible. The chemistry of oxygen and hydrogen is not enough in explanation of the threefold form ; and by the very necessity of the facts we are driven to the addition of heat. It is precisely so with protoplasm in its twofold form. The chemistry remaining the same in each (if it really does so), we are compelled to seek elsewhere a reason for the difference of living from dead protoplasm. As the differences of ice and steam from water lay not in the hydrogen and oxygen, but in the heat, so the difference of living from dead protoplasm lies not in the carbon, the hydrogen, the oxygen, and the nitrogen, but in the vital organization. In all cases, for the new quality, plainly, we must have a new explanation. The qualities of a steam-engine are not the results of its simple chemistry. We do apply to protoplasm the same conceptions, then, that are legitimate elsewhere, and in allocating properties and explaining phenomena we simply insist on Mr. Huxley's own distinction of "living or dead." That, in fact, is to us the distinction of distinctions, and we admit no vital action whatever, not even the dullest, to be the result of the *molecular* action of the protoplasm that displays it. The very protoplasm of the nettie-sting, with which Mr. Huxley begins, is already vitally organized, and in that organization as much superior to

its own molecules as the steam-engine, in its mechanism, to its own wood and iron. It were indeed as rational to say that there is no principle concerned in a steam-engine or a watch but that of its molecular forces, as to make this assertion of organized matter. Still there are degrees in organization, and the highest forms of life are widely different from the lowest. Degrees similar we see even in the inorganic world. The persistent flow of a river is, to the mighty reason of the solar system, in some such proportion, perhaps, as the rhizopod to man. In protoplasm, even the lowest, then, but much more conspicuously in the highest, there is, in addition to the molecular force, another force unsignalized by Mr. Huxley—the force of vital organization.

But this force is a rational unity, and that is an idea ; and this I would point to as a second form of the addition to the chemistry and physics of protoplasm. We have just seen, it is true, that an idea may be found in inorganic matter, as in the solar and sidereal systems generally. But the idea in organized matter is not one operative, so to speak, from without : it is one operative from within, and in an infinitely more intimate and pervading manner. The units that form the complement of an inorganic system are but independently and externally in place, like units in a procession ; but in what is organized there is no individual that is not sublated into the unity of the single life. This is so even in protoplasm. Mr. Huxley, it is true, desiderates, as result of mere ordinary chemical process, a life-stuff in mass, as it were in the web, to which he has only to resort for cuttings and cuttings in order to produce; by aggregation, what organized individual he pleases. But the facts are not so : we cannot have protoplasm in the

web, but the piece. There is as yet no *matter* of life ; there are still *cells* of life. It is no shred of protoplasm—no spoonful or toothpickful—that can be recognized as adequate to the function and the name. Such shred may wriggle a moment, but it produces nought, and it dies. In the smallest, lowest protoplasm cell, then, we have this rational unity of a complement of individuals that only are for the whole and exist in the whole. This is an idea, therefore; this is design : the organized concert of many to a single common purpose. The rudest savage that should, as in Paley's illustration, find a watch, and should observe the various contrivances all controlled by the single end in view, would be obliged to acknowledge—though in his own way—that what he had before him was no mere physical, no mere molecular product. So in protoplasm : even from the first, but, quite undeniably, in the completed organization at last, which alone it was there to produce ; for a single idea has been its one manifestation throughout. And in what machinery does it not at length issue ? Was it molecular powers that invented a respiration—that perforated the posterior ear to give a balance of air—that compensated the *fenestra ovalis* by a *fenestra rotunda*—that placed in the auricular sacs those *otolithes*, those express stones for hearing ? Such machinery ! The *chordæ tendineæ* are to the valves of the heart exactly adjusted check-strings ; and the contractile *columnæ carneæ* are set in, under contraction and expansion, to equalize their length to their office. Membranes, rods, and liquids—it required the express experiment of man to make good the fact that the inventor of the ear had availed himself of the most perfect apparatus possible for his purpose. And are we

to conceive such machinery, such apparatus, such trivances merely molecular? Are molecules adequate to such things—molecules in their blind passivity, dead, dull insensibility? Is it to molecular agency Huxley himself owes that “singular inward labor” of which he speaks, and without which all the protoplasm in the world would be useless to him? So, in the presence of these manifest ideas, it is impossible to attribute the single peculiar feature of protoplasm, its vitality, namely—to mere molecular chemistry. Protoplasm, it is true, breaks up into carbon, hydrogen, oxygen, and nitrogen, as water does into hydrogen and oxygen; but the watch breaks similarly up into brass, and steel, and glass. The loose material of the watch—even its chemical material if you will—cannot replace its weight, quite as accurately as the constituent carbon, etc., replace the weight of the protoplasm. But neither these nor those replace the vanished element which was alone the important element. Mr. Huxley saw no break in the series of steps in molecular organization; but, though not molecular, it is difficult to understand what more striding, what more absolute break could be desired than the break into an idea. It is of that break alone that we think in the watch; it is of that break alone that we should think in protoplasm which, far more cunningly, far more rationally, constructs a heart, an eye or an ear. That is the break of breaks, and explain it as we may, we can never explain it by molecules.

But, if inorganic elements as such are inadequate to account either for vital organization or the objective idea of design, much more are they inadequate, in the third place, to account for the subjective idea, for

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phenomena of thought as thought. Yet Mr. Huxley tells us that thought is but the expression of the molecular changes of protoplasm. This he only tells us ; this he does not prove. He merely says that, if we admit the functions of the lowest forms of life to be but "direct results of the nature of the matter of which they are composed," we must admit as much for the functions of the highest. We have not admitted Mr. Huxley's presupposition ; but, even with its admission, we should not feel bound to admit his conclusion. In such a mighty system of differences, there are ample room and verge enough for the introduction of new motives. We can say here at once, in fact, that as thought, let its connection be what it may with, has never been proved to result from, organization, no improvement of the proof required will be found in protoplasm. No one power that Mr. Huxley signalizes in protoplasm can account for thought : not alimentation, and not reproduction, certainly ; but not even contractility. We have seen already that there is no proof of contraction being necessary even for the simplest sensation ; but much less is there any proof of a necessity of contraction for the inner and independent operations of the mind. Mr. Huxley himself admits this. He says : "Speech, gesture, and every other form of human action are, in the long-run, resolvable into muscular contraction ;" and so, "even those manifestations of intellect, of feeling, and of will, which we rightly name the higher faculties, are not excluded from this classification, inasmuch as to every one *but the subject of them*, they are known only as transitory changes in the relative positions of parts of the body." The concession is made here, we see that these manifestations are differently known to the sub-

ject of them. But we may first object that, if even that privileged "every one but the subject" were limited to a knowledge of contractions, he would not know much. It is only because he knows, first of all, a thinker and willer of contractions that these themselves cease to be but passing externalities, and transitory contingencies. Neither is it reasonable to assert an identity of nature for contractions, and for that which they only represent. It would hardly be fair to confound either the receiver or the sender of a telegraphic message, with the movements which alone bore it, and without which it would have been impossible. The sign is not the thing signified, it is but the servant of the signifier—his own arbitrary mark—and intelligible, in the first place, only to him. It is the meaning, in all cases, that is alone vital; the sign is but an accident. To convert the internality into the arbitrary externality that simply expresses it, is for Mr. Huxley only an oversight. Your ideas are made known to your neighbors by contractions, therefore your ideas are of the same nature as contractions! Or, even to take it from the other side, your neighbor perceives in you contractions only, and therefore your ideas are contractions! Are not the vital elements here present the two correspondent internalities, between which the contractions constitute but an arbitrary chain of external communication, that is so now, but may be otherwise again? The ringing of the bell at the window is not precisely the dwarf within. Nor are Engineer Chappe's "wooden arms and elbow-joints jerking and furling in the air," to be identified with Engineer Chappe himself. For the higher faculties, even for speech, etc., assuredly Mr. Huxley might have well spared himself this superfluous and inapplicable reference to contraction.

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But, in the middle of it, as we have seen, Mr. Huxley concedes that these manifestations are differently known to the subject of them. If so, what becomes of his assertion of but a certain number of powers for protoplasm? The manifestations of the higher faculties are not known to the subject of them by contraction, etc. By what, then, are they known? According to Mr. Huxley, they can only be known by the powers of protoplasm; and therefore, by his own showing, protoplasm must possess powers other than those of his own assertion. Mr. Huxley's one great power of contractility, Mr. Huxley himself confesses to be inapplicable here. Indeed, in his *Physiology* (p. 193), he makes such an avowal as this: "We class *sensations*, along with *emotions*, and *volitions*, and *thoughts*, under the common head of states of *consciousness*; but what consciousness is we know not, and how it is that anything so remarkable as a state of consciousness comes about as the result of irritating nervous tissue, is just as unaccountable as the appearance of the Djinn when Aladdin rubbed his lamp in the story." Consciousness plainly was not muscular contraction to Mr. Huxley when he wrote his *Physiology*; it is only since then that he has gone over to the assertion of no power in protoplasm but the triple power, contractility, etc. But the truth is only as his *Physiology* has it—the cleft is simply, as Mr. Huxley acknowledges it there, absolute. On one side, there is the world of externality, where all is body by body, and away from one another—the boundless reciprocal exclusion of the infinite object. On the other side, there is the world of internality, where all is soul to soul, and away into one another—the boundless reciprocal inclusion of the infinite subject. This—even



while it is true that, for subject to be subject, and object, object, the boundless intussuscepted multiplicity of the single invisible point of the one is but the dimensionless casket into which the illimitable Genius of the other must retract and withdraw itself—is the difference of differences ; and certainly it is not internality that can be abolished before externality. The proof for the absoluteness of thought, the subject, the mind, is, on its side, pretty well perfect. It is not necessary here, however, to enter into that proof at length. Before passing on, I may simply point to the fact that, if thought is to be called a function of matter, it must be acknowledged to be a function wholly peculiar and unlike any other. In all other functions, we are present to processes which are in the same sense physical as the organs themselves. So it is with lung, stomach, liver, kidney, where every step can be followed, so to speak, with eye and hand ; but all is changed when we have to do with mind as the function of brain. Then, indeed, as Mr. Huxley thought in his Physiology, we are admitted, as if by touch of Aladdin's lamp, to a world absolutely different and essentially new—to a world, on its side of the incommunicable cleft, as complete, entire, independent, self-contained, and absolutely *sui generis*, as the world of matter on the other side. It will be sufficient here to allude to as much as this, with special reference to the fact that, so far as this argument is concerned, protoplasm has not introduced any the very slightest difference. All the ancient reasons for the independence of thought as against organization, can be used with even more striking effect as against protoplasm ; but it will be sufficient to indicate this, so much are the arguments in question a common

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property now. Thought, in fact, brings with it its own warrant ; or it brings with it, to use the phrase of Burns, "its patent of nobility direct from Almighty God." And that is the strongest argument on this whole side. Throughout the entire universe, organic and inorganic, thought is the controlling sovereign ; nor does matter anywhere refuse its allegiance. So it is in thought, too, that man has *his* patent of nobility, believes that he is created in the image of God, and knows himself a free-man of infinitude.

But the analogy, in the hands of Mr. Huxley, has, we have seen, a second reference—that, namely, to the excitants, if we may call them so, which *determine* combination. The *modus operandi*, Mr. Huxley tells us, of preëxisting protoplasm in determining the formation of new protoplasm, is not more unintelligible than the *modus operandi* of the electric spark in determining the formation of water ; and so both, we are left to infer, are perfectly analogous. The inferential turn here is rather a favorite with Mr. Huxley. "But objectors of this class," he says on an earlier occasion, in allusion to those who hesitate to conclude from dead to living matter, "do not seem to reflect that it is also, in strictness, true that we know nothing about the composition of any body whatever as it is." In the same neighborhood, too, he argues that, though impotent to restore to decomposed calc-spar its original form, we do not hesitate to accept the chemical analysis assigned to it, and should not, consequently, any more hesitate because of any mere difference of form to accept the analysis of dead for that of living protoplasm. It is certainly fair to point out that, if we bear ignorance and impotence with equanimity in one case, we may equally

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so bear them in another ; but it is not fair to convert ignorance into knowledge, nor impotence into power. Yet it is usual to take such statements loosely, and let them pass. It is not considered that, if we know nothing about the composition of any body whatever as it is, then we do know nothing, and that it is strangely idle to offer absolute ignorance as a support for the most dogmatic knowledge. If such statements are, as is really expected for them, to be accepted, yet not accepted, they are the stultification of all logic. Is the chemistry of living to be seen to be the same as the chemistry of dead protoplasm, because we know nothing about the composition of any body whatever as it is? We know perfectly well that black is white, for we are absolutely ignorant of either as it is! The *form* of the calc-spar, which (the spar) we *can* analyze, we cannot restore ; therefore the *form* of the protoplasm, which we *cannot* analyze, has nothing to do with the matter in hand ; and the chemistry of what is dead may be accepted as the chemistry of what is living! In the case of reasoning so irrelevant it is hardly worth while referring to what concerns the forms themselves ; that they are totally incommensurable, that in all forms of calc-spar there is no question but of what is physical, while in protoplasm the change of form is introduction into an entire new world. As in these illustrations, so in the case immediately before us. No appeal to ignorance in regard to something else, the electric spark, should be allowed to transform another ignorance, that of the action of preëxisting protoplasm, into knowledge, here into *the* knowledge that the two unknown things, because of non-knowledge, are—perfectly analogous! That this analogy does not exist—that the electric spark

and preëxisting protoplasm are, in their relative places, *not* on the same chemical level—this is the main point for us to see ; and Mr. Huxley's allusion to our ignorance must not be allowed to blind us to it. Here we have in a glass vessel so much hydrogen and oxygen, into which we discharge an electric spark, and water is the result. Now what analogy is it possible to perceive between this production of water by external experiment and the production of protoplasm by protoplasm ? The discrepancy is so palpable that it were impertinent to enlarge on it. The truth is just this, that the measured and mixed gases, the vessel, and the spark, in the one case, are as unlike the fortuitous food, the living organs, and the long process of assimilation in the other case, as the product water is unlike the product protoplasm. No ; that the action of the electric spark should be unknown, is no reason why we should not insist on protoplasm for protoplasm, on life for life. Protoplasm can only be produced by protoplasm, and each of all the innumerable varieties of protoplasm, only by its own kind. For the protoplasm of the worm we must go to the worm, and for that of the toad-stool to the toad-stool. In fact, if all living beings come from protoplasm, it is quite as certain that, but for living beings, protoplasm would disappear. Without an egg you cannot have a hen—that is true ; but it is equally true that, without a hen, you cannot have an egg. So in protoplasm ; which, consequently, in the production of itself, offers no analogy to the production, or precipitation by the electric spark, not of itself, but of water. Besides, if for protoplasm, preëxisting protoplasm, is always necessary, how was there ever a first protoplasm ?

Generally, then, Mr. Huxley's analogy does not hold, whether in the one reference or the other, and Mr. Huxley has no warrant for the reduction of protoplasm to the mere chemical level which he assigns it in either. That level is brought very prominently forward in such expressions as these: That it is only necessary to bring the chemical elements "together," "under certain conditions," to give rise to the more complex body, protoplasm, just as there is a similar expedient to give rise to water; and that, under the influence of pre-existing living protoplasm, carbonic acid, water, and ammonia disappear, and an equivalent weight of protoplasm makes its appearance, just as, under the influence of the electric spark, hydrogen and oxygen disappear, and an equivalent weight of water makes its appearance. All this, plainly, is to assume for protoplasm such mere chemical place and nature as consist not with the facts. The cases are, in truth, not parallel, and the "certain conditions" are wholly diverse. All that is said we can do at will for water, but nothing of what is said can we do at will for protoplasm. To say we can feed protoplasm, and so make protoplasm at will produce protoplasm, is very much, in the circumstances, only to say, and is not to say, that, in this way, we make a chemical experiment. To insist on a chemical analogy, in fact, between water and protoplasm, is to omit the differences not covered by the analogy at all—thought, design, life, and all the processes of organization; and it is but simple procedure to omit these differences only by an appeal to ignorance elsewhere.

It is hardly worth while, perhaps, to refer now again to the difference—here, however, once more incidentally suggested—between protoplasm and protoplasm.

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Mr. Huxley, that is, almost in his very last word on this part of the argument, seems to become aware of the bearing of this on what relates to materiality, and he would again stamp protoplasm (and with it life and intellect), into an indifferent identity. In order that there should be no break between the lowest functions and the highest (the functions of the fungus and the functions of man), he has "endeavored to prove," he says, that the protoplasm of the lowest organisms is "essentially identical with, and most readily converted into that of any animal." On this alleged reciprocal *convertibility* of protoplasm, then, Mr. Huxley would again found as well an inference of identity, as the further conclusion that the functions of the highest, not less than those of the lowest animals, are but the molecular manifestations of their common protoplasm.

Plainly here it is only the consideration, not of function, but of the alleged reciprocal *convertibility* that is left us now. Is this true, then? Is it true that every organism can digest every other organism, and that thus a relation of identity is established between that which digests and whatever is digested? These questions place Mr. Huxley's general enterprise, perhaps, in the most glaring light yet; for it is very evident that there is an end of the argument if all foods and all feeders are essentially identical both with themselves and with each other. The facts of the case, however, I believe to be too well known to require a single word here on my part. It is not long since Mr. Huxley himself pointed out the great difference between the foods of plants and the foods of animals; and the reader may be safely left to think for himself of *ruminantia* and *carnivora*, of soft bills and hard bills, of molluscs

and men. Mr. Huxley talks feelingly of the possibility of himself feeding the lobster quite as much as of the lobster feeding him ; but such pathos is not always applicable ; it is not likely that a sponge would be to the stomach of Mr. Huxley any more than Mr. Huxley to the stomach of a sponge..

But a more important point is this, that the functions themselves remain quite apart from the alleged convertibility. We can neither acquire the functions of what we eat, nor impart our functions to what eats us. We shall not come to fly by feeding on vultures, nor they to speak by feeding on us. No possible manure of human brains will enable a corn-field to reason. But if functions are inconvertible, the convertibility of the protoplasm is idle. In this inconvertibility, indeed, functions will be seen to be independent of mere chemical composition. And that is the truth : for functions there is more required than either chemistry or physics.

It is to be acknowledged—to notice one other incidental suggestion, for the sake of completeness, and by way of transition to the final consideration of possible objections—that Mr. Huxley would be very much assisted in his identification of differences, were but the theories of the molecularists, on the one hand, and of Mr. Darwin, on the other, once for all established. The three modes of theorizing indicated, indeed, are not without a tendency to approach one another ; and it is precisely their union that would secure a definitive triumph for the doctrine of materialism. Mr. Huxley, as we have seen—though what he desiderates is an autoplasmic living *matter* that, produced by ordinary chemical processes, is yet capable of continuing and developing itself into new and higher forms—still begins with

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the egg. Now the theory of the molecularists would, for its part, remove all the difficulties that, for materialism, are involved in this beginning ; it would place protoplasm undeniably at length on a merely chemical level ; and would fairly enable Mr. Darwin, supplemented by such a life-stuff, to account by natural means for everything like an idea or thought that appears in creation. The misfortune is, however, that we must believe the theory of the molecularists still to await the proof ; while the theory of Mr. Darwin has many difficulties peculiar to itself. This theory, philosophically, or in ultimate analysis, is an attempt to prove that design, or the objective idea, especially in the organic world, is developed *in time* by natural means. The time which Mr. Darwin demands, it is true, is an infinite time ; and he thus gains the advantage of his processes being allowed greater *clearness* for the understanding, in consequence of the *obscurity* of the infinite past in which they are placed, and of which it is difficult in the first instance to deny any possibility whatever. Still it remains to be asked, Are such processes credible in any time ? What Mr. Darwin has done in aid of his view is, first, to lay before us a knowledge of facts in natural history of surprising richness ; and, second, to support this knowledge by an inexhaustible ingenuity of hypothesis in arrangement of appearances. Now, in both respects, whether for information or even interest, the value of Mr. Darwin's contribution will probably always remain independent of the argument or arguments that might destroy his leading proposition ; and it is with this proposition that we have here alone to do. As said, we ask only, Is it true that the objective idea, the design which we see in the organized world, is the re-



sult in infinite time of the necessary adaption of living structures to the peculiarities of the conditions by which they are surrounded ?

Against this theory, then, its own absolute generalization may be viewed as our first objection. In ultimate abstraction, that is, the only agency postulated by Mr. Darwin is time—infinite time ; and as regards actually existent beings and actually existent conditions, it is hardly possible to deny any possibility whatever to infinitude. If told, for example, that the elephant, if only obliged *infinitely* to run, might be converted into the stag, how should we be able to deny ? So also, if the lengthening of the giraffe's neck were hypothetically attributed to a succession of dearths in infinite time that only left the leaves of trees for long-necked animals to live on, we should be similarly situated as regards denial. Still it can be pointed out that ingenuity of natural conjecture has, in such cases, no less wide a field for the negation than for the affirmation ; and that, on the question of fact, nothing is capable of being determined. But we can also say more than that—we can say that any fruitful application even of *infinite time* to the *general problem of difference* in the world is inconceivable. To explain all from an absolute beginning requires us to commence with nothing ; but to this nothing time itself is an addition. Time is an entity, a something, a difference added to the original identity : whence or how came time ? Time cannot account for its own self ; how is it that there is such a thing as time ? Then no conceivable brooding even of infinite time could hatch the infinitude of space. How is it there is such a thing as space ? No possible clasps of time and space, further, could ever conceivably thicken into mat-

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ter. How is it there is such a thing as matter? Lastly, so far, no conceivable brooding, or even gyrating, of a single matter in time and space could account for the specification of matter—carbon, gold, iodine, etc.—as we see and know it. Time, space, matter, and the whole inorganic world, thus remain impassive to the action even of infinite time; all *these* differences remain incapable of being accounted for so.

But suppose no curiosity had ever been felt in this reference, which, though scientifically indefensible, is quite possible, how about the transition of the inorganic into the organic? Mr. Huxley tells us that, for food, the plant needs nothing but its bath of smelling-salts. Suppose this bath now—a pool of a solution of carbonate of ammonia; can any action of sun, or air, or electricity, be conceived to develop a cell—or even so much lump-protoplasm—in this solution? The production of an initial cell in any such manner will not allow itself to be realized to thought. Then we have just to think for a moment of the vast differences into which, for the production of the present organized world, this cell must be distributed, to shake our heads and say we cannot well refuse anything to an infinite time, but still we must pronounce a problem of this reach hopeless.

It is precisely in conditions, however, that Mr. Darwin claims a solution of this problem. Conditions concern all that relates to air, heat, light, land, water, and whatever they imply. Our second objection, consequently, is, that conditions are quite inadequate to account for present organized differences, from a single cell. Geological time, for example, falls short, after all, of infinite time; or, in known geological eras, let us calculate them as liberally as we may, there is not time

enough to account for the presently-existing varieties,  
 from one, or even several, primordial forms. So to  
 speak, it is not *in* geological time to account for the  
 transformation of the elephant into the stag from ac-  
 celeration, or for that of the stag into the elephant from  
 retardation, of movement. And we may speak sim-  
 ilarly of the growth of the neck of the giraffe, or even  
 of the elevation of the monkey into man. Moreover,  
 time apart, conditions have no such power in themselves.  
 It is impossible to conceive of animal or vegetable  
 effluvia ever creating the nerve by which they are felt,  
 and so gradually the Schneiderian membrane, nose, and  
 whole olfactory apparatus. Yet these effluvia are the  
 conditions of smell, and, *ex hypothesi*, ought to have  
 created it. Did light, or did the pulsations of the air,  
 ever by any length of time, indent into the sensitive  
 cell, eyes, and a pair of eyes—ears, and a pair of ears?  
 Light conceivably might shine for ever without such a  
 wonderfully complicated result as an eye. Similarly,  
 for delicacy and marvellous ingenuity of structure, the  
 ear is scarcely inferior to the eye; and surely it is pos-  
 sible to think of a whole infinitude of those fitful and  
 fortuitous air-tremblings, which we call sound, without  
 indentation into anything whatever of such an organ.

A third objection to Mr. Darwin's theory is, that the  
 play of natural contingency in regard to the vicissi-  
 tudes of conditions, has no title to be named *selection*.  
 Naturalists have long known and spoken of the "influ-  
 ence of accidental causes; but Mr. Darwin was the  
 first to apply the term *selection*, to the action of these,  
 and thus convert accident into design. The agency to  
 which Mr. Darwin attributes all the changes which he  
 would signalize in animals is really the fortuitous con-

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tingency of brute nature ; and it is altogether fallacious to call such process, or such non-process, by a term involving foresight and a purpose. We have here, indeed, only a metaphor wholly misapplied. The German writer who, many years ago, said "even the *genera* are wholly a prey to the changes of the external universal life," saw precisely what Mr. Darwin sees, but it never struck him to style contingency selection. Yet, how dangerous, how infectious, has not this ungrounded metaphor proved ! It has become a *principle*, a *law*, and been transferred by very genuine men into their own sciences of philology and what not. People will wonder at all this by-and-by. But to point out the inapplicability of such a word to the processes of nature referred to by Mr. Darwin, is to point out also the impossibility of any such contingencies proceeding, by graduated rise, from stage to stage, into the great symmetrical organic system—the vast plan—the grand harmonious whole—by which we are surrounded. This rise, this system, is really the objective idea ; but it is utterly incapable of being accounted for by any such agency as natural contingency in geological, or infinite, or any time. But it is this which the word selection tends to conceal.

We may say, lastly, in objection, here, that, in the fact of "reversion" or "atavism," Mr. Darwin acknowledges his own failure. We thus see that the species as species is something independent, and holds its own *insita vis naturæ* within itself.

Probably it is not his theory, then, that gives value to Mr. Darwin's book ; nor even his ready ingenuity, whatever interest it may lend : it is the material information it contains. The ingenuity, namely, verges

somewhat on that Humian expedient of natural conjecture so copiously exemplified, on occasion of a few trite texts, in Mr. Buckle. But that natural conjecture is always insecure, equivocal, and many-sided. It may be said that ancient warfare, for example, giving victory always to the personally ablest and bravest, must have resulted in the improvement of the race ; or that, the weakest being always necessarily left at home, the improvement was balanced by deterioration ; or that the ablest were necessarily the most exposed to danger, and so, etc., etc., according, to ingenuity *usque ad infinitum*. Trustworthy conclusion is not possible to this method, but only to the induction of facts, or to scientific demonstration.

Neither molecularists nor Darwinians, then, are able to level out the difference between organic and inorganic, or between genera and genera or species and species. The differences persist despite of both ; the distributed identity remains unaccounted for. Nor, consequently, is Mr. Darwin's theory competent to explain the objective idea by any reference to time and conditions. Living beings do exist in a mighty chain from the moss to the man ; but that chain, far from founding, is founded in the idea, and is not the result of any mere natural *growth* of this into that. That chain is itself the most brilliant stamp, the sign-manual, of design. On every ledge of nature, from the lowest to the highest, there is a life that is *its*,—a creature to represent it, reflect it—so to speak, pasture on it. The last, highest, brightest link of this chain is man ; the incarnation of thought itself, which is the summation of this universe ; man, that includes in himself all other links and their single secret—the personified universe, the subject of the world.

Mr. Huxley makes but small reference to thought ; he only tucks it in, as it were, as a mere appendicle of course.

It may be objected, indeed—to reach the last stage in this discussion—that, if Mr. Huxley has not disproved the conception of thought and life “as a something which works through matter, but is independent of it,” neither have we proved it. But it is easy for us to reply that, if “*independent of*” means here “*unconnected with,*” we have had no such object. We have had no object whatever, in fact, but to resist, now the extravagant assertion that all organized tissue, from the lichen to Leibnitz, is alike in faculty, and again the equally extravagant assertion that life and thought are but ordinary products of molecular chemistry. As regards the latter assertion, we have endeavored to show that the processes of vital organization (as self-production, etc.) belong to another sphere, higher than, and very different from, those of mechanical juxtaposition or chemical neutralization ; that life, then, is no mere product of matter as matter ; that if no life can be pointed to independent of matter, neither is there any life-stuff independent of life ; and that life, consequently, adds a new and higher force to chemistry, as chemistry a new and higher force to mechanics, etc. As for thought, the endeavor was to show that it was as independent on the one side as matter on the other, that it controlled, used, summed, and was the reason of matter. Thought, then, is not to be reached by any bridge from matter, that is a hybrid of both, and explains the connection. The relation of matter to mind is not to be explained as a transition, but as a *contrecoup*. In this relation, however, it is not the material, but the mental side, which the whole universe declares to be the dominant one.

As regards any objection to the arguments which we have brought against the identity of protoplasm, again, these will lie in the phrase, probably, "difference not of kind, but degree," or in the word "modification." The "phrase" may be now passed, for generic or specific difference must be allowed in protoplasm, if not for the overwhelming reason that an infinitude of various kinds exist in it, each of which is self-productive and uninterchangeable with the rest, then for Mr. Huxley's own reason, that plants assimilate inorganic matter and animals only organic. As for the objection "modification," again, the same consideration of generic difference must prove fatal to it. This were otherwise, indeed, could but the molecularists and Mr. Darwin succeed in destroying generic difference ; but in this, as we have seen, they have failed. And this will be always so : who dogs identity, difference dogs him. It is quite a justifiable endeavor, for example, to point out the identity that obtains between veins and arteries on the one hand, as between these and capillaries on the other ; but all the time the difference is behind us ; and when we turn to look, we see, for circulation, the valves of the veins and the elastic coats of the arteries as opposed to one another, and, for irrigation, the permeable walls of the capillaries as opposed to both.

Generic differences exist then, and we cannot allow the word "modification" to efface them in the interest of the identity claimed for protoplasm. Brain-protoplasm is not bone-protoplasm, nor the protoplasm of the fungus the protoplasm of man. Similarly, it is very questionable how far the word "modification" will warrant us in regarding with Mr. Huxley the "ducts, fibres, pollen, and ovules" of the nettle as identical with the

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protoplasm of its sting. Things that originate alike may surely eventuate in others which, chemically and vitally, far from being mere modifications, must be pronounced totally different. Such eventuation must be held competent to what can only be named generic or specific difference. The "child" is only "*father* of the man"—it is not the man ; who, moreover, in the course of an ordinary life, we are told, has totally changed himself, not once, but many times, retaining at the last not one single particle of matter with which he set out. Such eventuations, whether called modifications or not, certainly involve essential difference. And so situated are the "ducts, fibres, pollen, and ovules" of the nettle, which, whether compared with the protoplasm of the nettle-sting, or with that in which they originated, must be held to here assumed, by their own actions, indisputable differences, physical, chemical, and vital, or in form, substance, and faculty.

Much, in fact, depends on definition here ; and, in reference to modification, it may be regarded as arbitrary when identity shall be admitted to cease and difference to begin. There are the old Greek puzzles of the Bald Head and the Heap, for example. How many grains, or how many hairs, may we remove before a heap of wheat is no heap, or a head of hair bald ? These concern quantity alone ; but, in other cases, bone, muscle, brain, fungus, tree, man, there is not only a quantitative, but a qualitative difference ; and in regard to such differences, the word modification can be regarded as but a cloak, under which identity is to be shuffled into difference, but remain identity all the same. The brick is but modified clay, Mr. Huxley intimates, bake it and paint it as you may ; but is the difference introduced by





the baking and painting to be ignored? Is what Mr. Huxley calls the "artifice" not to be taken into account, leave alone the "potter?" The strong firm rope is about as exact an example of modification proper—modification of the weak loose hemp—as can well be found; but are we to exclude from our consideration the whole element of difference due to the hand and brain of man? Not far from Burn's Monument, on the Calton Hill of Edinburgh, there lies a mass of stones which is potentially a church, the former Trinity College Church. Were this church again realized, would it be fair to call it a mere modification of the previous stones? Look now to the egg and the full-feathered fowl. Chaucer describes to us the cock, "hight chaunteclere," that was to his "faire Pertelotte" so dear:—

"His comb was redder than the fine corall,  
Embattled, as it were a castle-wall;  
His bill was black, and as the jet it shone;  
Like azure were his legges and his tone (toes);  
His nailes whiter than the lilie flour,  
And like the burned gold was his color."

Would it be even as fair to call this fine fellow—comb, wattles, spurs, and all—a modified yolk, as to call the church but modified stones? If, in the latter case, an element of difference, altogether undeniable, seems to have intervened, is not such intervention at least quite as well marked in the former? It requires but a slight analysis to detect that all the stones in question are marked and numbered; but will any analysis point out within the shell the various parts that only need arrangement to become the fowl? Are the men that may take the stones, and, in a re-erected Trinity College Church, realize anew the idea of its architect,



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in any respect more wonderful than the unknown disposers of the materials of the fowl? That what realizes the idea should, in the one case, be from without, and, in the other, from within, is no reason for seeing more modification and less wonder in the latter than the former. There is certainly no more reason for seeing the fowl in the egg, and as identical with the egg, than for seeing a re-built Trinity College Church as identical with its unarranged materials. A part cannot be taken for the whole, whether in space *or in time*. Mr. Huxley misses this. He is so absorbed in the identity out of which, that he will not see the difference into which, progress is made. As the idea of the church has the stones, so the idea of the fowl has the egg, for its commencement. But to this idea, and in both cases, the terminal additions belong, quite as much as the initial materials. If the idea, then, add sulphur, phosphorus, iron, and what not, it must be credited with these not less than with the carbon, hydrogen, etc., with which it began. It is not fair to mutter modification, as if it were a charm to destroy all the industry of time. The protoplasm of the egg of the fowl is no more the fowl than the stones the church; and to identify, by juggle of a mere word, parts in time and wholes in time so different, is but self-deception. Nay, in protoplasm, as we have so often seen, difference is as much present at first as at last. Even in its germ, even in its initial identity, to call it so, protoplasm is already different, for it issues in differences infinite.

Omission of the consideration of difference, it is to be acknowledged, is not now-a-days restricted to Mr. Huxley. In the wonder that is usually expressed, for example, at Oken's *identification* of the skull with so many

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vertebrae, it is forgot that there is still implicated the wonder which we ought to feel at the unknown power that could, in the end, so *differentiate* them. If the cornea of the eye and the enamel of the teeth are alike but modified protoplasm, we must be pardoned for thinking more of the adjective than of the substantive. Our wonder is how, for one idea, protoplasm could become one thing here, and, for another idea, another so different thing there. We are more curious about the modification than the protoplasm. In the difference, rather than in the identity, it is, indeed, that the wonder lies. Here are several thousand pieces of protoplasm ; analysis can detect no difference in them. They are to us, let us say, as they are to Mr. Huxley, identical in power, in form, and in substance ; and yet on all these several thousand little bits of apparently indistinguishable matter an element of difference so pervading and so persistent has been impressed, that, of them all, not one is interchangeable with another ! Each seed feeds its own kind. The protoplasm of the gnat will no more grow into the fly than it will grow into an elephant. Protoplasm is protoplasm : yes, but man's protoplasm is man's protoplasm, and the mushroom's the mushroom's. In short, it is quite evident that the word modification, if it would conceal, is powerless to withdraw, the difference ; which difference, moreover, is one of kind and not of degree.

This consideration of possible objections, then, is the last we have to attend to ; and it only remains to draw the general conclusion. All animal and vegetable organisms are alike in power, in form, and in substance, only if the protoplasm of which they are composed is similarly alike ; and the functions of all animal and



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vegetable organisms are but properties of the molecular affections of their chemical constituents, only if the functions of the protoplasm, of which they are composed, are but properties of the molecular affections of *its* chemical constituents. In disproof of the affirmative in both clauses, there has been no object but to demonstrate, on the one hand, the infinite non-identity of protoplasm, and, on the other, the dependence of its functions upon other factors than its molecular constituents.

In short, the whole position of Mr. Huxley, that all organisms consist alike of the same life-matter, which life-matter is, for its part, due only to chemistry, must be pronounced untenable—nor less untenable the materialism he would found on it.



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